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Conservation priorities in the Philippine Archipelago

PAUL HAUGE, JOHN TERBORGH, BLAIR WINTER and JOHN PARKINSON

To determine how conservation planning should most efficiently proceed so as to protect all the Philippine Archipelago's terrestrial vertebrate species, we took the island having the largest total number of species (Mindanao), identified the island containing the greatest number of species not found on Mindanao, and repeated this procedure until an asymptote began to be approached. The most critical islands from the point of view of conservation thus prove to be Mindanao, Luzon, and Palawan. Together they contain 86% of all Philippine terrestrial vertebrate species.

Single-island endemics (Philippine species that occur on only one island) constitute an important part (176 species, or 28%) of the terrestrial vertebrate fauna. Mindanao, Luzon and Palawan are again the key islands, containing 72% of all single-island endemics. The creation and management of parks and reserves on these three islands should therefore have the highest priority in the overall conservation plan for the Philippines. Smaller islands, however, also merit attention since they hold significant numbers of endemic species, these being especially vulnerable to extinction. The trends in both total species numbers and in numbers of single-island endemics are strongly convergent in the four classes of vertebrates, suggesting that a conservation plan optimal for, say, mammals, would also be optimal or nearly so for other taxa.

The Philippine Archipelago consists of a vast array of more than 7,000 islands lying between 5 and 20°N and between 117 and 127°E in the western Pacific Ocean. The biota of these islands is exceptionally rich and includes large numbers of species that occur nowhere else in the world. Within the archipelago the biogeographic situation is exceedingly complex. Species richness may vary greatly from one island to the next, and many islands possess unique endemics. Furthermore, there are marked gradients in species composition along the chain resulting from the fact that the archipelago has been colonized by species invading from the south and south-east through Mindanao, from the south-west through Palawan, and from the north through Luzon (Inger 1954), although the Luzon (from Taiwan) and Palawan routes have been rejected for certain taxa (Heaney 1986). The picture has been made still more complex by the occurrence of numerous small-scale radiations within the archipelago itself. Superimposed on these patterns are the effects of a Pleistocene history of repeated land-bridge connections between many of the islands, and possibly between the Philippines and the emergent Sunda Shelf.

All these layers of complexity have produced intricate patterns of distribution. While these very intricacies have provided a major source of fascination for biogeographers (Taylor 1922, Dickerson 1928, Inger 1954, Leviton 1959, Diamond and Gilpin 1983, Heaney 1986), they are bound to confound any studied attempt to formulate an overall conservation plan for the Philippines. In the absence of a thorough biogeographic analysis, it would be difficult to answer such questions as: Which islands contain the greatest concentrations of species? Which islands are richest in endemic forms? Are the patterns for different taxonomic groups (e.g. birds, mammals, reptiles, etc.) similar or dissimilar? How many parks, and on which islands, would be required to protect, say, 90% of the fauna? The difficulty in answering these questions stems from the fact that the available information is often scattered through a miscellany of guidebooks, expedition reports, and taxonomic treatises. But to ignore these questions in planning for the future management and expansion of the Philippines' reserves would certainly lead to mistakes, mistakes that it might not be possible to rectify later because time is quickly running out.

The urgency of the need for vigorous conservation work in the Philippines is made plainly evident by recent statistics on the rate and extent of deforestation. The Philippines rank high among tropical countries in both rate of deforestation and extent of area deforested. The percentage of the nation's land area covered by forests and woodland plummeted between the mid-1960s and the early 1980s from 57% to 41%. By the first half of the 1980s, the rate of deforestation had 'slowed' to an average of 91,000 ha per year (World Resources Institute/International Institute for Environment and Development 1986), due perhaps in part to the nation's economic problems at that period. However, rapid deforestation, compounded by continuing economic development and a population that is expected to jump by some 37% by the year 2000 (World Resources Institute/International Institute for Environment and Development 1986), clearly poses a serious threat of extinction to a major portion of the rich and unique Philippine fauna and flora.

Still, the existing framework of government parks and conservation programmes makes us confident that the information presented here can and will be used to avoid costly errors in conservation planning and to ensure the full protection of the precious biological heritage of the Philippines. Accomplishing that task requires that priorities be clearly specified to assure the greatest possible benefit from each unit of land brought under protection.

METHODS

From available literature we attempted to extract species lists of mammals, birds, reptiles and amphibians for each of the 30 or so major islands. While in theory this may seem simple and straightforward, in practice we met with many frustrations, such as ranges given as 'throughout the archipelago', when other evidence suggested the contrary, and the incompleteness of the faunal surveys of many of the islands. Poorly understood distributions and systematics necessitated the complete exclusion of bats, although bats face the same extinction pressures as other taxa. (L. Heaney reports to us the possible extinction of one bat species, *Dobsonia chapmani*, and the endangered status of two others, *Acerodon lucifer* and *Nyctimene rabori*, among the 72 species of Chiroptera recorded in the Philippines: clearly, much more work on Philippine bats is needed, especially in light of their economic value in pollination, seed dispersal, and insect control.) Some of the sources included evaluations of how carefully each island had been explored and collected in, but more often this critical information was left up to the reader's imagination. Many of the islands have not been covered adequately by zoologists. This proved to be the greatest difficulty we encountered. We were also required to do a certain amount of detective work to ascertain the synonymies in a kaleidoscopic nomenclature. In the end we were obliged to concentrate our attention on the six best studied islands, and to lump everything else under the heading of 'other islands'.

We examined the data in two ways. First, we looked at the overall pattern of faunal richness simply as the total number of species recorded for each island. To identify conservation priorities in an objective fashion, we asked the question: How should conservation planning proceed in order to protect all of the archipelago's terrestrial vertebrate species, and do so as efficiently (in terms of land area) as possible? We answered this question by starting with the island having the largest total number of species, and then asking which island contains the greatest number of species not found on the first, repeating this procedure until an asymptote began to be approached. Second, we asked more specifically about endemic species whose distributions within the archipelago are confined to single islands, and repeated the procedure described above. Single-island endemics are of critical importance because of their uniqueness and because their continued existence within the Philippines will require very specific action.

The data came from a mix of expedition reports, field guides, and taxonomic monographs. We endeavoured to be as up-to-date as possible by contacting specialists in several groups and enlisting their help, but the fact remains that the biogeography of Philippine vertebrates is far less completely known than one would wish. The results are not a perfect reflection of reality: they are a summary of what has been learned to date about the fauna of an unusually complex and numerous set of islands.

RESULTS

All terrestrial vertebrates

Looking at the fauna as a whole, it is apparent that the second largest island, Mindanao, holds the greatest number of species in all but one of the groups of vertebrates considered (Table 1). Luzon, the largest island, has almost as many species, including a sizeable proportion (33%) that do not occur on Mindanao. Although fifth in size, Palawan comes next in our ranking because of its highly distinctive fauna, nearly half of which is made up of species which do not occur on either Mindanao or Luzon.

From the point of view of conservation, it is obvious that these three islands are the most important. Not only do they hold the vast majority of the total number of terrestrial vertebrate species, but they hold most that occur nowhere else in the archipelago, as discussed below. Together, Mindanao, Luzon and Palawan harbour 86% of all terrestrial vertebrates recorded for the archipelago. Values for individual groups range from 77% for mammals to 92% for birds. These results emphasize the vital importance of the larger islands as species banks. The smaller islands in general contain reduced and repetitive subsets of the faunas of the nearest large islands, a finding that has been noted for other archipelagos as well (Diamond and Marshall 1977, Terborgh *et al.* 1978, Patterson and Atmar 1986).

Single-island endemics

We come now to the problem of single-island endemics, species that occur (or are known to occur) only in the Philippines, and on only one island within the archipelago (Table 2). Taken together, these single-island endemics are an important element of the Philippine fauna, contributing 176 species, or 28% of the total (excluding bats) of 625 terrestrial vertebrate species. Developing a conservation plan for these species should have the highest priority, but doing so is an especially difficult task because of the distinct and

Table 1. Species numbers for indigenous mammals, birds, reptiles and amphibians on selected Philippine islands.

1. Total number of indigenous species on the island.
2. Additional species not found on any island to the left.
3. Total number of 'other' islands was 16 for mammals, approximately 24 for birds, 24 for snakes, 49 for skinks, 59 for gekkonid lizards, and 22 for amphibians. The Sulu Archipelago was counted as one island (the listing 'Sulu Archipelago' appears in many distributional records). Only the six listed islands were considered for 'other lizards'.
4. This is a conservative estimate. L. Heaney (pers. comm.) estimates that there may be as many as 93 indigenous non-volant mammal species in the Philippines.
5. Mammals exclusive of bats (from Heaney 1986).
6. Resident land birds, from Delacour and Mayr (1946), Amadon and duPont (1970), duPont (1971, 1976), Parkes (1971, 1973), Rabor (1977), Erickson and Heideman (1983).
7. From Savage (1950), Leviton (1952, 1957, 1959), Brown and Alcala (1970), Rabor *et al.* (1970).
8. From Brown and Alcala (1970, 1978, 1980).
9. From Brown and Alcala (1970), Rabor *et al.* (1970).
10. From Rabor (1952), Inger (1954), Leviton (1955), Alcala (1957, 1958), Brown and Alcala (1967, 1970, 1974), Rabor *et al.* (1970).
11. NA = data not available.

	Mindanao		Luzon		Palawan		Negros		Mindoro		Bohol		Others[3]		TOTAL
	T[1]	A[2]	T	A	T	A	T	A	T	A	T	A	T	A	
Mammals[5]	25	–	28	21	23	19	8	2	14	6	9	0	40	11	84[4]
Birds[6]	197	–	195	39	122	43	143	6	127	5	117	0	230	12	302
Snakes[7]	36	–	31	15	26	15	23	5	13	1	14	0	44	6	78
Skinks and gekkonid lizards[8]	41	–	29	17	13	10	20	7	13	0	18	0	53	10	85
Other lizards[9]	12	–	5	1	3	0	5	0	6	2	6	1	NA[11]	NA	16
Amphibians[10]	32	–	17	7	19	10	12	1	9	1	18	2	41	7	60
TOTAL	343	–	305	100	206	97	211	21	182	15	182	3	408	46	625

exacting spatial requirements of each one of them. Fortunately, the key islands remain the same: Mindanao, Luzon and Palawan. These collectively contain 72% of the single-island endemics. Conversely, however, 28% of the single-island endemics occur on islands besides these three, including large proportions of the single-island endemic lizards (29%), snakes (32%), mammals (33%) and amphibians (47%). Discordant trends exist in some taxa. Mindoro, for example, has nine endemic birds and mammals but only three such reptiles, while Negros has just four endemic birds and mammals but seven such reptiles. The 'other' islands (islands besides the six principal islands studied here) collectively contain 14% of the single-island endemics, including an especially large proportion (37%) of the single-island endemic amphibians. Thus these 'other' islands should not be neglected.

DISCUSSION

The priorities we have developed here are based on the simple optimality criterion of protecting the largest number of species, particularly endemic species, per unit of land set aside. Fortunately, the task was facilitated by the fact that the four major classes of terrestrial vertebrates – mammals, birds, reptiles, and amphibians – show highly concordant patterns of distribution. Thus, in specifying priorities, we were spared the unhappy job of making value judgements, such as whether a bird is intrinsically more worthy of protection than a rat or a snake. Another fortunate coincidence is that endemics are concentrated on the most species-rich islands, making it possible to preserve both quantity and quality on the same islands. The high degree of concurrence among taxa in the distributional patterns we have examined not only makes it easy to specify such priorities as to which islands need protection, but it provides a basis for confidence that the distributions

Table 2. Numbers of single-island endemic species[1] on selected Philippine islands.

1. Species that occur only in the Philippines, and on only one island within the archipelago.
2. Total number of single-island endemics in that taxonomic category.
3. Percentage of all single-island endemics in that taxonomic category.
4. See Table 1, note 3.
5. All references as in Table 1.
6. NA = data not available.

	Mindanao		Luzon		Palawan		Negros		Mindoro		Bohol		Others[4]		TOTAL
	T[2]	%[3]	T	%	T	%	T	%	T	%	T	%	T	%	
Mammals[5]	9	21	18	42	3	7	1	2	6	14	0	0	6	14	43
Birds	14	29	14	29	12	25	3	6	3	6	0	0	2	4	48
Snakes	8	29	6	21	5	18	5	18	1	4	0	0	3	11	28
Skinks and gekkonid lizards	8	24	9	27	8	24	2	6	0	0	0	0	6	18	33
Other lizards	2	40	0	0	0	0	0	0	2	40	1	20	NA[6]	NA	5
Amphibians	4	21	3	16	3	16	0	0	1	5	1	5	7	37	19
TOTAL	45	26	50	28	31	18	11	6	13	7	2	1	24	14	176

of other taxa, i.e. plants and invertebrates, are fundamentally similar. Indeed, the 'critical faunas analysis' of Collins and Morris (1985) for swallowtail butterflies showed Palawan (32 species), Mindanao (28 species) and Luzon (26 species) again to be the most important Philippine islands, embracing between them all 49 Philippine species of swallowtails. Their work followed that of Ackery and Vane-Wright (1984), who coined the term 'critical faunas analysis' and applied the concept to milkweed butterflies on a global scale, finding, *inter alia*, that Luzon, Negros, and Mindanao are among the most important locations for a hypothetical worldwide conservation effort for that group of butterflies. The work presented here is quite similar to critical faunas analysis, which both Ackery and Vane-Wright (1984) and Collins and Morris (1985) applied to worldwide species distributions and used to make recommendations for action on a global scale.

The pronounced concentration of the fauna on Mindanao, Luzon and Palawan means that preserves on these islands can be highly efficient in protecting large numbers of species simultaneously. Preserves on other islands, though less efficient that these three islands at protecting species, are still essential if all species are to be protected. Special attention should be given to the needs of endemic species that occur only on the smaller islands. They are highly vulnerable to extinction, since smaller islands are likely to contain only one or a few populations of a given species and are more susceptible to complete deforestation. Well-targeted efforts on certain small islands could yield disproportionate conservation results. However, it should be remembered that while endemic species on a given island may often be generally sympatric, and therefore protectable in a single park (e.g. on Mindoro, or Negros, or Bohol), this will not always be the case. For instance, new species finds on the poorly known south-eastern peninsula of Luzon indicate that many species may occur only on that part of the island, thus suggesting a high level of allopatric endemism within the island (Heaney 1986).

With no first-hand knowledge of either the geography or the fauna of the Philippines, we have not ventured to go further than to suggest the islands on which preserves could have the greatest benefit. The best choice of sites on these islands would depend on many factors: the state of the habitat, human population densities, local variation in species diversity, the spatial requirements of endemics, etc. Many of the islands contain complex environmental gradients, climates that range from seasonally dry to permanently wet, and montane as well as lowland vegetation types. The mountains of Luzon, for example, harbour a rich assemblage of endemic rodents, while the montane avifauna of Mindanao is especially well differentiated. Reptiles are most abundant in the lowlands. Special considerations such as these would have to be taken into account in detailed planning (Brown and Alcala 1964).

It would also help to know which species are able to live in second growth and other common types of human-created habitat, but this sort of information is not included in handbooks or taxonomic monographs. The chances are good that more than half of the species pool can make use of disturbed environments (*cf.* Terborgh and Weske 1969). This being so, biological reserves could be designed expressly to benefit the minority of species that absolutely require unaltered natural conditions.

The final question we wish to consider is that of the size of existing and future reserves. How large should they be, or perhaps more appropriately, how big is big enough? There has been a good deal of controversy in the literature over this issue – for a juxtaposition of contrasting viewpoints, see Simberloff and Abele (1975) and the ensuing rejoinders: Diamond (1976), Terborgh (1976), Whitcomb *et al.* (1976), Simberloff and Abele (1976). It is unfortunate in our opinion that the debate has centred on the largely bogus question of whether several small patches of habitat may contain more species than a single large patch of equal aggregate area. Obviously, the answer depends on how the various patches are situated with respect to the variety of available habitat types. Far more importantly, parks should include genetically viable populations of the particular species one is trying to protect. To make the point with an absurd example, it may be possible to protect a square kilometre of forest that contains the nest of a given bird species, but that is irrelevant if five years later the birds are no longer present. The object is to preserve species and whole ecosystems over the long run, not just to include one or more individuals of as many species as possible at the outset. There can be no doubt that large areas are more effective over the long run.

Nevertheless, the question of how large is large enough is still a valid and necessary one to ask. The answer has to be tailored to the particular objectives at hand. It might be possible to assure the continued existence of an amphibian, for example, by protecting a few springs or preserving the vegetative cover along a watercourse. At the other extreme, making sure that the Philippine Eagle *Pithecophaga jefferyi* is still with us 100 years from now is perhaps the most challenging conservation objective in the Philippines. If enough habitat can be protected in Mindanao and Luzon to perpetuate the eagle populations of these two islands, it seems probable that a majority of all Philippine vertebrates will be secure along with them.

What must be kept in mind is that the spatial requirements of species differ enormously. If we begin with the big and spectacular and give them the highest priority, then many lesser creatures of little popular appeal can ride their coattails to perpetuity. The ones that are left out can then perhaps be afforded special attention on a smaller scale. We cannot realistically expect that any conservation plan will be accepted that optimizes purely biological criteria. But what we should realize is that the political concerns based on the popular appeal of certain impressive, adorable, or 'charismatic' creatures can potentially by channelled into very constructive action.

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REFERENCES

Ackery, P. R. and Vane-Wright, R. I. (1984) *Milkweed butterflies: their cladistics and biology.* London: British Museum (Natural History).

Alcala, A. C. (1957) Philippine notes on the ecology of the giant marine toad. *Silliman J.* 4: 90–96.

Alcala, A. C. (1958) Amphibians of Negros Island. *Silliman J.* 5:171–174.

Amadon, D. and duPont, J. E. (1970) Notes on Philippine birds. *Nemouria* 1.

Brown, W. C. and Alcala, A. C. (1964) Relationship of the herpetofaunas of the non-dipterocarp communities to that of the dipterocarp forest of southern Negros Island, Philippines. *Senkenbergiana Biologica* 45: 591–611.

Brown, W. C. and Alcala, A. C. (1967) A new frog of the genus *Oreophryne* and a list of amphibians from Camiguin Island, Philippines. *Proc. Biol. Soc. Washington* 80: 65–68.

Brown, W. C. and Alcala, A. C. (1970) The zoogeography of the herpetofauna of the Philippine Islands, a fringing archipelago. *Proc. Calif. Acad. Sci.* 38: 105–130.

Brown, W. C. and Alcala, A. C. (1974) New frogs of the genus *Platymantis* (Ranidae) from the Philippines. *Occ. Pap. Calif. Acad. Sci.* 113: 1–12.

Brown, W. C. and Alcala, A. C. (1978) *Philippine lizards of the family Gekkonidae.* Dumaguete City, Philippines: Silliman University Natural Science Monograph Series No. 1.

Brown, W. C. and Alcala, A. C. (1980) *Philippine lizards of the family Scincidae.* Dumaguete City, Philippines: Silliman University Natural Science Monograph Series No. 2.

Collins, N. M. and Morris, M. G. (1985) *Threatened swallowtail butterflies of the world: the IUCN Red Data Book.* Gland, Switzerland and Cambridge, U. K.: International Union for Conservation of Nature and Natural Resources.

Delacour, J. T. and Mayr, E. (1946) *Birds of the Philippines.* New York: Macmillan.

Diamond, J. M. (1976) Island biogeography and conservation: strategy and limitations. *Science* 193: 1027–1029.

Diamond, J. M. and Gilpin, M. E. (1983) Biogeographic umbilici and the origin of the Philippine avifauna. *Oikos* 41: 307–321.

Diamond, J. M. and Marshall, A. G. (1977) Distributional ecology of New Hebridean birds: a species kaleidoscope. *J. Anim. Ecol.* 46: 703–727.

Dickerson, R. E. (1928) *Distribution of life in the Philippines.* Manila: Bureau of Printing.

duPont, J. E. (1971) *Philippine birds.* Greenville, Delaware: Delaware Museum of Natural History.

duPont, J. E. (1976) Notes on Philippine birds (No. 4): Additions and corrections to *Philippine Birds. Nemouria* 17.

Erickson, K. R. and Heideman, P. D. (1983) Notes on the avifauna of the Balinsasayao rainforest region, Negros Oriental, Philippines. *Silliman J.* 30: 63–72.

Heaney, L. R. (1986) Biogeography of mammals in S. E. Asia: estimates of colonization, extinction, and speciation. *Biol. J. Linn. Soc.* 28(1–2): 127–165.

Inger, R. F. (1954) Systematics and zoogeography of Philippine amphibia. *Fieldiana (Zool.)* 33: 183–531.

Leviton, A. E. (1952) A new Philippine snake of the genus *Calamaria. J. Washington Acad. Sci.* 42: 239–240.

Leviton, A. E. (1955) New distributional records for Philippine amphibians. *Copeia* 1955(3): 258.

Leviton, A. E. (1957) A review of the Philippine snakes of the genus *Oxyrhabdium* (Serpentes: Colubridae). *Wasmann J. Biol.* 15: 285–303.

Leviton, A. E. (1959) Systematics and zoogeography of Philippine snakes. Ph.D. dissertation, Stanford University.

Lewis, R. E. (1986) A rain-forest raptor in danger. *Oryx* 20: 170–175.

Parkes, K. C. (1971) Taxonomic and distributional notes on Philippine birds. *Nemouria* 4.
Parkes, K. C. (1973) Annotated list of the birds of Leyte Island, Philippines. *Nemouria* 11.
Patterson, B. D. and Atmar, W. (1986) Nested subsets and the structure of insular mammalian faunas and archipelagos. *Biol. J. Linn. Soc.* 28: 65–82.
Rabor, D. S. (1952) Preliminary notes on the giant toad, *Bufo marinus* (Linn.), in the Philippine Islands. *Copeia* 1952(4): 281–282.
Rabor, D. S. (1977) *Philippine birds and mammals*. Quezon City: University of the Philippines Press.
Rabor, D. S., Alcala, A. C. and Gonzales, R. B. (1970) A list of the land vertebrates of Negros Island, Philippines. *Silliman J.* 17: 297–316.
Savage, J. M. (1950) Two new blind snakes (genus *Typhlops*) from the Philippine Islands. *Proc. Calif. Zool. Club* 1: 49–54.
Simberloff, D. S. and Abele, L. G. (1975) Island biogeography theory and conservation practice. *Science* 191: 285–286.
Simberloff, D. S. and Abele, L. G. (1976) Island biogeography and conservation: strategy and limitations. *Science* 193: 1029–1030.
Taylor, E. H. *The snakes of the Philippine Islands*. Manila: Bureau of Printing.
Terborgh, J. (1976) Island biogeography and conservation: strategy and limitations. *Science* 193: 1029–1030.
Terborgh, J., Faaborg, J. and Brockmann, H. J. (1978) Island colonization by Lesser Antillean birds. *Auk* 95: 59–72.
Terborgh, J. and Weske, J. S. (1969) Colonization of secondary habitats by Peruvian birds. *Ecology* 50: 765–782.
Whitcomb, R. F., Lynch, J. F., Opler, P. A. and Robbins, C. S. (1976) Island biogeography and conservation: strategy and limitations. *Science* 193: 1030–1032.
World Resources Institute/International Institute for Environment and Development (1986) *World Resources 1986*. New York: Basic Books, Inc.

Paul Hauge, Conservation Law Foundation of New England, 3 Joy Street, Boston, Massachusetts 02108–1497, U.S.A.
John Terborgh, Blair Winter and John Parkinson, Department of Biology, Princeton University, Princeton, New Jersey 08544, U.S.A.